ORIGINAL ARTICLE

Uses and abuses of paediatric electroencephalography

CME

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Objective To investigate whether requests for standard paediatric electroencephalograms accord with guideline recommendations, subsequent changes in clinical management according to reported results, and extent to which the service meets waiting time targets.

Design Case series.

Setting Regional hospital, Hong Kong.

Patients All patients aged less than 18 years who underwent electroencephalography between December 2009 and February 2010.

Main outcome measures Appropriateness of the electroencephalogram request and the impact of its findings on clinical management.

Results A total of 109 patients were recruited, but requests for standard electroencephalograms were considered 'inappropriate' with respect to guidelines in 44% of the patients, of which 50% were made to diagnose 'funny turns'. The standard electroencephalogram contributed to the diagnosis or management in only 28% of patients. In all of the latter, the request for an electroencephalogram had been appropriate. Non-specialists made referrals for 86% of the patients. Inadequate information was provided in 66% of the requests. Standard electroencephalograms were performed within guideline targets, the wait being less than 4 weeks in 95% of requests.

Conclusion An effective electroencephalogram service was being provided, though abuses were common. These were mainly because of misconceptions regarding the role and limitations of standard electroencephalograms. Through an educative, non-confrontational approach, and with time to explain guideline recommendations to clinicians, sustainable change in practice could be achieved so as to benefit patients, clinicians, and service provision.

New knowledge added by this study

- Misconceptions about the diagnostic capability of standard electroencephalogram (EEG) in paediatrics are common.
- Approximately 44% of corresponding standard EEG requests were deemed 'inappropriate' with respect to guidelines, of which 50% were to yield a diagnosis for 'funny turns', 23% in patients with febrile convulsions, 23% as a form of monitoring in persons with established epilepsy.
- Requests made appropriately were highly associated with EEG results that were contributory to clinical management.

Implications for clinical practice or policy

- The EEG can support the diagnosis and classification of epilepsy in an appropriate clinical context.
- The standard EEG was not helpful (or even misleading) when requests were inappropriate.

Key words
Child; Electroencephalography; Hospitals, district; Practice guidelines as topic; Utilization review

Hong Kong Med J 2012;18:25-9

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Introduction

Electroencephalogram (EEG) has gained a reputation as a diagnostic test with a range of indications. "Uses of EEGs" amount to "abuses of EEG" if the roles and limitations of standard EEGs are not clearly appreciated. There has been unrestricted access to standard EEGs in most Hong Kong hospitals. Most requests are from non-specialists. Hence, there is considerable potential for unnecessary requests and misinterpretation of the results.

兒童腦電圖的使用及被濫用情況

目的 探討醫生是否按指引的建議使用標準兒童腦電圖以及按報告結果來作出臨床管理上的變動，並研究兒童腦電圖服務是否合乎輪候時間的目標。

設計 病例系列研究。

安排 香港一所分區醫院。

患者 2009年12月至2010年2月期間進行腦電圖的18歲以下的病人。

主要結果測量 要求使用腦電圖的適切性及其對臨床管理的影響。

結果 共109個病例使用腦電圖。如果按指引建議的標準作評估，44%屬「不正確」使用腦電圖的病例，當中有50%的病例把腦電圖用作診斷眩暈。只有28%的病例作腦電圖後對診斷或臨床處理有幫助，遂被納入正確使用腦電圖的病例。病例中有86%由非專科醫生轉介，另66%並未提供足夠資料以衡量是否須作腦電圖。有95%的病例輪候腦電圖時間少於四星期，即達至腦電圖輪候時間的目標。

結論 縱然有被濫用的情況，本院仍能有效提供腦電圖服務。濫用的情況很可能是對標準腦電圖的角色及其限制存有誤解。透過教育及非對抗性的方法，並慢慢向醫生講解指引的建議，相信可以持續改變臨床實踐，最終對病人、醫生，甚至服務的提供都有利。

Literature regarding the use of standard EEGs in routine clinical practice is limited. Previous studies have suggested that misconceptions about their diagnostic capability were common, and that consequently they use it suboptimally. Nicolaides et al[1] reported that two-fifths of EEG requests in general paediatrics could be considered inappropriate. Smith et al[2] observed that non-specialists seem to use the EEG as a diagnostic tool in patients with 'funny turns' even when it was likely to yield misleading rather than useful information. To promote optimal use of EEG services, guidelines and expert guidance outlining appropriate reasons for requesting an EEG have been produced.[3-5] The aims of this study were to evaluate use of the paediatric EEG service with respect to: (1) whether standard EEG requests were appropriate (according to guideline recommendations), (2) whether subsequent changes in clinical management according to reported findings were appropriate, and (3) to what extent the service met waiting time targets.

Methods

All children aged less than 18 years who underwent standard EEGs between December 2009 and February 2010 in Tuen Mun Hospital were identified. Tuen Mun Hospital is the only regional hospital that provides EEG services to the paediatric population in the northwest section of Hong Kong. Requests for EEGs and clinical notes were reviewed. On the request forms, doctors need to explicitly state a provisional diagnosis, provide clinical information and the purpose of the examination. Requests for sleep-deprived EEG and long-term video EEG were excluded from this analysis. Medical records were considered essential to assess request appropriateness and subsequent EEG results contributing to clinical management. Purposes for EEG requests were classified as 'appropriate' or 'inappropriate' according to international guidelines and published expert opinion (Table 1).[3-6] Results of EEG were defined as normal, non-specifically abnormal, epileptiform and specific findings such as encephalopathic. The potential contribution of the EEG to management was ascribed to one of the three categories (Table 2).[7] Data were analysed using IBM SPSS Statistics version 19.0.0 using Pearson's Chi squared test.

Results

A total of 109 patients were recruited; 44% of standard EEG requests were considered 'inappropriate' with

TABLE 1. 'Appropriate' and 'inappropriate' reasons for electroencephalogram (EEG) requests

'Appropriate'	'Inappropriate'
Epilepsy	• 'Funny turn'
• Definite/probable epilepsy/seizure	• Established epilepsy—clinical change in seizures with the exception of absence
• Classify newly diagnosed epilepsy	• Febrile convulsion
• Established epilepsy: subclinical EEG changes leading to symptoms	
• Status epilepticus	
Non-epilepsy	
• Encephalopathy	
• Neurodegeneration	
• Organic brain disturbances	

TABLE 2. Contribution of electroencephalograms (EEGs) to management

Category	Criteria
Support diagnosis/help in making diagnosis	EEG supported the clinical history and gave enough evidence to make a diagnosis
Altered management	Clinical management changed as a result of EEG findings—EEG assists in classification of epilepsy and affects subsequent drug choice, investigations, or prognosis
Non-contributory	EEG had no effect on subsequent management

respect to guidelines, of which 24 (50%) were for the diagnosis of 'funny turns'—11 (23%) for febrile convulsions, 11 (23%) in persons with established epilepsy using EEG as a form of monitoring, and two (4%) where no reason could be identified (Table 3). Of the 61 appropriate requests, 54 (89%) were to support a diagnosis of epilepsy, when there was a strong clinical suspicion of epilepsy.

Findings of EEG were as follows: normal in 65 (60%), epileptiform in 22 (20%), encephalopathic in 13 (12%), encephalopathic and epileptiform in 4 (4%), and non-specific in another 5 (5%). The EEG contributed to the diagnosis or management in only 31 (28%) of the cases; for all of these patients the requests were appropriate (Table 4). The EEG was not contributory to clinical management in all inappropriate requests. Thirty (49%) of the 61 appropriately requested EEGs were not contributory to the management. There was a highly significant association between EEG results contributory to clinical management and whether the request was made appropriately (P<0.001). Non-specialists made referrals in 94 (86%) of cases, of which 42 (45%) were inappropriately requested. Specialists made 15 referrals and only nine (60%) were considered appropriate. However, the proportional difference in appropriateness between the two groups was not statistically significant (P=0.735).

The purpose for requesting EEGs was not provided in 40% of requests. When it was stated, 26 (40%) of requests were considered inappropriate. Information was inadequate in 66% of EEG referrals. When requested, EEGs were performed within 2 days in 85% of in-patients and 95% met the guideline target wait of 4 weeks.

TABLE 3. Reasons for electroencephalogram (EEG) requests

Reason for EEG requests	No.
Appropriate	
Definite/probable seizure or epilepsy	54
Subclinical seizure	3
Status epilepticus	2
Encephalopathy	2
Inappropriate	
'Funny turn'	24
Febrile seizure	11
Epilepsy: EEG as therapeutic monitor	11
Unknown	2

TABLE 4. Contribution of electroencephalogram to management

Contribution	No.
Support/help diagnosis	13
Altered management	4
Both support and altered management	13
Non-contributory	79

Discussion

We demonstrated that almost half of the standard paediatric EEG requests were inappropriate, mainly because of misconceptions about its role and limitations. If the requests are made improperly or with insufficient information, they could be regarded as an abuse of the EEG service. The EEG service could be considered useful in that it confirmed the diagnosis or altered management, although only about one-quarter of all instances were appropriately requested. Resorting to standard EEGs could be regarded as unhelpful or even potentially misleading in all instances of inappropriate requests. We believe the use of our EEG service is typical of that encountered in most regional hospitals in Hong Kong, and our results can probably be generalised.

Electroencephalogram requests were considered to be inappropriate because of the misconceptions about its uses in various clinical settings, notably in patients with 'funny turns'. One of the commonest abuses was 'to exclude epilepsy', which is almost impossible, as the diagnosis of epilepsy being clinical. In the majority of patients with funny turns, interictal EEGs are indistinguishable from normal findings. Moreover, so-called false-positive EEG findings can be as high as 0.5%,[8] if there are no clinical features to suggest epilepsy. This increases the risk of misdiagnosing epilepsy and its attendant important consequences, including inappropriate drug treatment and the psychological trauma of being 'labelled' epileptic. Linzer et al[9] systematically reviewed 534 EEGs performed in eight studies on syncope. They were diagnostic in only 1.5% of instances, out of which one-quarter had a history of seizures. The guidelines recommend EEG as 'a diagnostic tool' if seizure activity is present

based on the clinical history and physical findings. Moreover, patients who have had seizure activity, yet normal findings on EEG, no postictal symptoms, and no response to anticonvulsant medications should be evaluated for possible cardiac syncope.[9]

Provided one recognises that a normal routine EEG does not exclude its diagnosis, it can play a major role in evaluation of epilepsy[3-5] by supporting the diagnosis and aiding classification of epilepsy in a proper clinical context. Classification of epilepsy into seizure types and syndromes is important because prognosis and treatment can vary in different epileptic syndromes. Localising EEG features can often raise suspicion of intracranial pathology that requires subsequent confirmation by neuroimaging. The sensitivity of a single interictal EEG is not high. Routine EEG recorded in patients with epilepsy yield no epileptiform activity in about 50% of cases.[10,11] Marsan and Zivin[11] reviewed 1824 EEGs in adults with epilepsy; one-fifth never exhibited epileptiform discharges in the course of repeated EEG examinations, half showed epileptiform discharges on some occasions, and only 30% yields epileptiform discharges consistently.

Standard EEGs are considered helpful in predicting the risk of recurrence after a first seizure, and if abnormal it is becoming more common to treat patients even after one seizure. The risk of relapse is increased if the EEG shows generalised spike-wave discharges.[6,12] Moreover, EEGs can help in the evaluation of encephalopathies (metabolic, infectious, and degenerative) and focal brain lesions (cerebral infarction, haemorrhage, neoplasms). In paediatric practice, they might help to determine the level of brain maturation.[5] In the management of status epilepticus, EEGs are helpful indicators of treatment efficacy, depth of anaesthesia, and whether the patient is in status epilepticus, especially when it comes to disentangling symptomatic epilepsy and behavioural change.[3,4,6] By contrast, EEGs are not useful in following the therapeutic efficacy of antiepileptic drugs, except in absence epilepsy where quantification of spike-wave episodes is helpful in monitoring treatment impact.[5,6,13]

The proportion of inappropriate EEG requests noted in present study was comparable to that reported by Smith et al,[2] who retrospectively evaluated 368 patients who underwent EEG in a district general hospital, and found 56% of the testing to be inappropriate (based on similar guidelines available at that time). Similarly, according to an audit performed in a general paediatric service, two-fifths of EEG requests were considered inappropriate.[1] Pearce and Cock[7] reported a lower rate of 26% inappropriate requests in an audit at neurology/neurosurgery referral centre. Neurologists/epileptologists appeared better than non-specialists in terms of appropriate referrals.[7]

Standard EEG contributed to management in only 28% of instances in the present study, of which the figure is similar to the rate of 22% reported by Pearce and Cock.[7] Binnie[14] observed that 60% of referrals were "routine EEG to assess control" in patients with epilepsy and found that results influenced management in only 3% of instances, and 40% when the referral policy was changed. Smith et al[2] reported that when the number of inappropriate requests decreased, the number of 'useful' EEGs increased. We also found that appropriate requests were more likely to result in 'useful' EEGs and 'useless' ones were more likely after inappropriate referrals.

This study also evaluated target waiting times. Investigations by EEG are more sensitive when performed early,[15,16] and should be performed within 4 weeks of any requests made according to recommended guidelines.[3,4] We demonstrated that an effective service has been provided, because 95% met the target waiting times, though sustainability may be questioned if abuses are common. Strategies to decrease inappropriate requests are required to optimise service utilisation. Restructuring of request forms, coupled with changes in referral policy, should be considered.

A limitation of our study was the non-inclusion of sleep-deprived EEG. Previous studies have shown that sleep deprivation in children can increase the diagnostic yield by as much as 35%.[17,18] The release of potential technical capacity from reduction of inappropriate request can be better used for sleep-deprived EEG and telemetry services.

Non-confrontational and educative approaches (presenting audit findings, guideline sharing) may help reduce unnecessary requests. The greater understanding of the limitations and roles of EEGs may reduce the risk of misdiagnosing epilepsy.

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